

UCRL- 94767
PREPRINT

CIRCULATION COPY
SUBJECT TO RECALL
IN TWO WEEKS

RECENT IMPLOSION EXPERIMENTS AT NOVA

M.D. Cable, S.M. Lane, S.G. Prussin
S.G. Glendinning, D.H. Munro, S.P. Hatchett
K.G. Estabrook and L.J. Suter

This paper was prepared for submittal to
6th International Conference on
Hi-Power Particle Beams
JAPAN
June 9-12, 1986

June 1986

Lawrence
Livermore
National
Laboratory

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement recommendation, or favoring of the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

RECENT IMPLSION EXPERIMENTS AT NOVA*

M.D. Cable, S.M. Lane, S.G. Prussin, S.G. Glendinning, D.H. Munro,
S.P. Hatchett, K.G. Estabrook, and L.J. Suter

Lawrence Livermore National Laboratory
University of California
P. O. Box 808
Livermore, CA 94550

Both electron (direct) and x-ray (indirect) driven implsions of DT targets have been done using ~20 kJ of 0.35 μm light from the ten beam Nova laser facility. The direct drive targets (glass microballoons with nominal dimensions of 1000 μm x 2 μm and DT pressures of 12-14 atm.) produced neutron yields in excess of 10^{13} and fusion efficiencies $>0.15\%$. Implosion characteristics were low fuel areal density ($<1 \text{ mg/cm}^2$) and high ion temperatures (~10 keV) in the imploded fuel. The first ablatively compressed, x-ray driven targets shot at Nova reached high confinement conditions ($n \times \theta$ product of $\sim 10^{14}$). They produced neutron yields of $3-5 \times 10^{10}$, ion temperatures of 1-2 keV and areal densities estimated to be $>10 \text{ mg/cm}^2$. Recent experiments will be described, with particular emphasis on measurements made using neutron diagnostics. We acknowledge the University of Rochester Laboratory for Laser Energetics for their contribution to the direct drive experiments and KMS Fusion for providing targets.

A primary goal of the Nova facility is to achieve high gain target conditions in a scaled implsion. Achieving this would not produce breakeven or gain due to insufficient target mass, but would result in high compression at a fuel ion temperature (θ_i) of about 3 keV. In an effort to reach this goal, initial implsion experiments on DT gas filled targets have begun. Both electron (direct) and x-ray (indirect) driven implsions have been done.

Direct drive targets were glass microballoons with nominal dimensions of 1000 μm diameter with 2 μm wall thickness and contained DT pressures of 12-14 atm. These targets were irradiated with the ten Nova beams at 2 kJ each for a total of 20 kJ of 0.35 μm light in a 1 ns square pulse. Tangential focussing was used. Neutron yields (Y_n) of

1×10^{13} were typically obtained which corresponds to a fusion efficiency of $E_{\text{fus}}/E_{\text{laser}} = 0.15\%$.

Fuel ion temperatures (θ_i) were measured on two shots using a neutron time-of-flight system (i.e., see Ref. 1) with a ~20 m flight path. Due to the large size of the Nova chamber (4.6 m diameter) and the use of a hole in the concrete target room wall as a collimator, the scattered neutron background is quite low. Figure 1 shows a sample oscilloscope trace for a θ_i measurement. θ_i values of 10.6 ± 1.5 and 7.8 ± 1.5 keV were measured for the two shots.

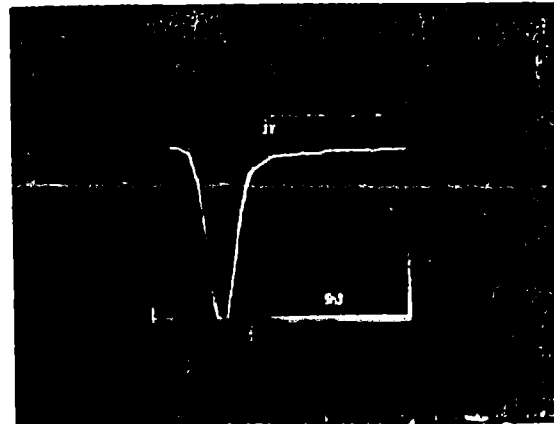


Fig. 1: Sample oscilloscope trace for θ_i measurement. Flight path was 19.8 m; observed θ_i was 7.8 ± 1.5 keV.

Fuel areal densities ($\langle \rho R \rangle$) were measured using CR-39 track detectors to observe neutron scattered D and T ("knock-ons").² $\langle \rho R \rangle$ values of $< 1 \text{ mg/cm}^2$ were observed. $\langle \rho R \rangle$, Y_n , and θ_i are consistent with a simple model of a uniform temperature and density burn confined for a time limited by fuel disassembly at sound speed.

Indirect drive targets were ablatively compressed to higher densities with lower fuel

ion temperatures. Neutron yields of 3×10^{10} and 5×10^{10} were measured for two shots. θ_1 values of 1.7 ± 0.3 keV were measured for both shots. Assuming fuel disassembly time limited by sound speed and a uniform temperature and density burn, these values of Y_n and θ_1 lead to an estimate of $\langle \rho R \rangle > 10 \text{ mg/cm}^2$. This value of $\langle \rho R \rangle$ corresponds to a density of 30-40 times liquid.

Diagnostic techniques to better characterize these implosions are under development, with particular emphasis on a technique to measure fuel $\langle \rho R \rangle$ for high compression targets. Measurement of DT neutrons produced from DD fuel is a prime candidate for this.^{3,4} Future experiments will use cryogenic targets and laser pulse shaping as methods to achieve higher compressions.

References

1. R. A. Lerche, L. W. Coleman, J. W. Houghton, D. R. Speck, and E. K. Storm, Appl. Phys. Lett. **31**, 645 (1977).
2. S. Kacenjar, L. M. Goldman, A. Enterberg, and S. Skupsky, J. Appl. Phys. **56**, 2027 (1984).
3. T. E. Blue and D. B. Harris, Nucl. Sci. and Engin. **47**, 463 (1981).
4. N. Miyanaga, H. Azechi, R. O. Stapf, K. Itoga, H. Nakaishi, H. Shiraga, M. Yamanaka, T. Yamanaka, R. Tsuji, S. Ido, K. Nishihara, T. Yabe, Y. Izawa, C. Yamanaka, and S. Morinoby, presented at 6th Topical Conference on High Temperature Plasma Diagnostics, March 9-13, 1986, Hilton Head Island, South Caroline, USA.